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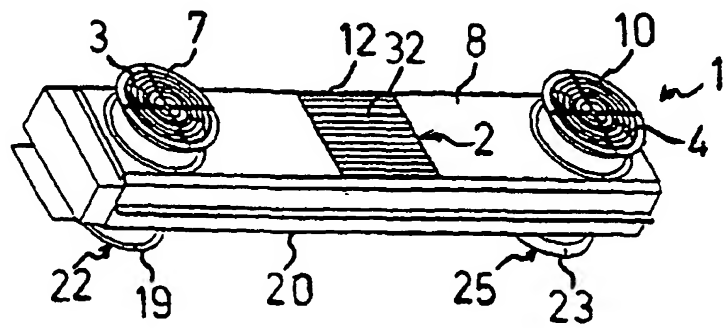
(54) Title: COOLING FAN UNIT

(57) Abstract



A fan unit for cooling of heat-generating equipement comprises an air-cooled heat-exchanging element (2) which is adapted to remove heat from said equipment. The heat-exchanging element (2) has a front which is formed in a first tubular duct having a first duct opening (7), through which a first fan (3) blows air towards the front of the heat-exchanging element (2), and a second duct opening (10) through which a second fan (4) blows air towards the front of the heat-exchanging element (2), and a third duct opening (12) which is formed between the first and the second duct opening (7, 10), so that the airflows generated by the first and the second fan (3, 4) meet at the third duct opening (12) so as to leave, in the form of one airflow, the duct through said opening (12).

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COOLING FAN UNIT

The present invention relates to a fan unit for cooling of heat-generating equipment, such as electric components, said unit comprising an air-cooled heat-exchanging element which is adapted to remove heat from said equipment, and at least two fans which are adapted to blow air towards the heat-exchanging element to increase its heat removing effect.

Such a fan unit is known from e.g. US-A-5,638,895. The advantages of the unit disclosed in said specification include, apart from the high cooling effect thanks to the two fans, also greater interruption reliability than in fan units with a single fan only. The reason is, of course, that the probability of both fans failing at the same time is extremely small, and that the processor cooled by means of the fan unit may in most cases remain in operation also after failure of one of the fans.

Starting from the known fan unit, the object of the invention is to minimise the consumption of energy for operating the fans and, in case of failure of one of them, to achieve a higher cooling effect of the remaining fan.

According to the invention, this object is achieved with a fan unit of the type mentioned by way of introduction by the heat-exchanging element having a front which is formed inside a first tubular duct having a first duct opening which is formed in a duct wall at a first end of the duct and through which a first fan is adapted to blow air towards the front of the heat-exchanging element, a second duct opening which is formed in the duct wall at an opposite end of the duct and through which a second fan is adapted to blow air towards the front of the heat-exchanging element, and a third duct opening which is formed between the first and the second duct opening, so that airflows generated by the first and the second fan

meet at the third duct opening to leave the duct in the form of one airflow through said opening.

Thanks to the fact that the airflows generated by the fans are conducted through a duct from both ends of the duct to meet at an intermediate opening and be removed therethrough, the airflows are used more efficiently than in the prior-art solution, in which a certain amount of leakage and a reduction of the cooling effect caused thereby are difficult to avoid. Moreover, in case of failure or switching off of one of the fans in the fan unit according to the invention, the remaining fan is always used more efficiently than before since the airflow generated by this fan will then to a great extent pass the third duct opening to leave the duct only after passing the entire heat-exchanging element through the duct opening with the damaged or switched-off fan.

According to an embodiment of the invention, the duct openings are formed in the duct wall opposite to the heat-exchanging element. The advantage of this solution is that the fans then blow air straight towards the heat-exchanging element and that mounting of the fan unit in, for example, an apparatus housing is facilitated by the three duct openings belonging together then being capable of leading into three corresponding vent openings formed in one and the same wall of the housing.

In a variant of the invention, a first temperature sensor is adapted to connect, by a means of a thermostat, the first fan when a first temperature level is exceeded, and a second temperature sensor is adapted to connect, by means of a thermostat, also the second fan when a second temperature level higher than the first temperature level is exceeded. In this way, it will be possible to save energy in an extremely simple way when a great cooling effect is not required as well as to accomplish continued operation with a moderately reduced cooling effect without any direct monitoring of the actual fan function. Besides, it is in this way possible to achieve an automa-

tic, significant reduction of the fan noise at night when the required cooling effect normally is smaller, which is a great advantage in built-up areas. It has also been found suitable in experiments to arrange the temperature sensors so as to sense the temperature levels at the third duct opening since this is directly contacted by the airflows generated by the fans.

Especially when cooling electric components which are mountable directly on a refrigerated wall, the heat-exchanging element is suitably designed as a cooling element provided with cooling flanges. On this cooling element, said components are mounted on the side facing away from the cooling flanges, and, for better guiding of the airflows in the duct, the cooling flanges of the cooling element extend essentially in the longitudinal direction of the duct in such manner that the duct is divided by the cooling flanges into a plurality of parallel passages.

In another variant of the invention, the heat-exchanging element has a back which is formed inside a second tubular duct having a first duct opening which is formed in a duct wall at a first end of the duct and through which a third fan is adapted to blow air towards the back of the heat-exchanging element, a second duct opening which is formed in the duct wall at an opposite end of the duct and through which a fourth fan is adapted to blow air towards the back of the heat-exchanging element, and a third duct opening formed between the first and the second duct opening, so that airflows generated by the third and the fourth fan meet at the third duct opening to leave, in the form of one airflow, the duct once more through this opening. This variant is, despite its simplicity, thanks to the totally four fans, very efficient and most reliable, which has been proved by measurements carried out by the applicant. Assuming that the fan unit in operation of all four fans yields an effect of 100%, these measurements have, in operation of

three fans, demonstrated a remaining effect of up to 85%, in operation of one fan per duct a remaining effect of up to 72% when the fans operated diagonally, and up to 65% when the fans operated in parallel. The excellent yield especially in operation of three fans and of two diagonally operating fans is explained by the fact that the airflows in the two ducts in such operation are at least partly directed countercurrently to each other.

The latter variant is particularly usable for cooling of electric equipment in apparatus housings which can be intended, for example, for base stations in mobile telephone networks, in which case according to the invention a second duct communicates with a hermetically sealed chamber (i.e. the inner space of the apparatus housing), in which said heat-generating equipment is arranged.

In a manner similar to that described above, a first temperature sensor is in the latter variant suitably adapted to connect, by means of a thermostat, a fan at the first duct and a fan at the second duct, when a first temperature level is exceeded in the chamber, and a second temperature sensor is adapted to connect, by means of a thermostat, also the remaining fans when a second temperature level which is higher than the first temperature level is exceeded in the chamber. Conveniently, the temperature sensors are arranged to sense temperature levels in the chamber at the third duct opening of the second duct. It will thus be possible to reliably control, with simple means, the fan effect and, thus, the cooling effect whether varying temperatures in the chamber depend on varying ambient temperatures or failure of a fan.

According to a preferred embodiment of the invention, the heat-exchanging element has a back which is formed inside a second tubular duct having a first duct opening which is formed in a duct wall at a first end of the duct and a second duct opening which is formed in

the duct wall at an opposite end of the duct, a third fan being adapted to generate an airflow which flows into the second duct through the first duct opening and out of this duct through the second duct opening. It has been found that this somewhat simpler embodiment compared with the embodiment comprising four fans makes it possible to provide, at a somewhat reduced airflow through the second duct, a lower temperature of the air leaving this duct, which makes this embodiment especially usable for cooling of heat-generating equipment in hot climates.

In experiments, it has been found convenient to arrange in the preferred embodiment the third opening of the first duct closer to the first than to the second opening since in this way it will be possible to provide a greater difference in temperature between the front and the back of the heat-exchanging element in the duct part between the second and the third duct opening.

It will be appreciated that the duct openings also in the preferred embodiment can be formed in the duct wall opposite to the heat-exchanging element, and that the second duct can also communicate with a hermetically sealed chamber, in which said heat-generating equipment is arranged.

For the fan unit according to the preferred embodiment, a temperature sensor is preferably adapted to regulate the speed of the first and the second fan in dependence on the temperature level in the chamber, the advantage of this solution being that it is the one that causes the minimum energy consumption.

Like in the solution with the thermostats at the second duct, the temperature sensor is suitably adapted to sense the temperature level in the chamber at the second duct opening of the second duct since in this position a most accurate temperature indication will be obtained.

Moreover, in the preferred embodiment the third fan is preferably arranged at the second duct opening of the

second duct. This arrangement means that the fan operates in an extracting manner and thus in the air cooled by means of the heat-exchanging element, which contributes to increasing the service life of the fan.

Finally, in the solutions with the second duct it has been found convenient to design the heat-exchanging element as a sheet metal element which is folded in an essentially meandering manner and whose ridges and intermediate troughs inside the ducts extend in such manner in the longitudinal direction of the ducts that these are each divided into a plurality of parallel passages. As a result, the airflows in the ducts on each side of the sheet metal element are given large surfaces that are necessary for efficient heat exchange and, owing to the folding of the sheet metal element, they are also oriented in a favourable manner in the ducts.

The invention will now be described in more detail with reference to the accompanying schematic drawings, in which

Fig. 1 is a perspective view of a first fan unit according to the invention;

Fig. 2 is a side view of the fan unit in Fig. 1;

Fig. 3 is top plan view of the fan unit in Fig. 1;

Fig. 4 is a side view of a second fan unit according to the invention, of which unit only one end and a few details which are normally concealed are shown;

Fig. 5 is a cross-sectional view of the unit in Fig. 4 seen along the line V-V in this Figure;

Fig. 6 is a first top plan view of an alternative fan unit;

Fig. 7 is a broken-up side view of the alternative fan unit; and

Fig. 8 is a second top plan view of the alternative fan unit.

In the specification, claims and abstract, the same reference numerals are used for equivalent details in the various embodiments.

The fan unit 1 in Figs 1-3 is adapted to cool electric equipment in an apparatus housing which is generally designated C and not shown in more detail. The fan unit 1 is essentially box-shaped and comprises two tubular ducts 6, 18 which will be described in more detail below. The first of these ducts 6 has three openings 7, 10, 12 formed in one large face 8 of the box-shaped fan unit 1 while the second duct 18 parallel with the first duct has three openings 19, 23, 26 formed in the opposite large face 20 of the fan unit 1.

In the first and second opening 7, 10 of the first duct 6, one axial fan 3, 4 each is mounted, and in the first and second opening 19, 23 of the second duct 18 one axial fan 22, 25 each is mounted. Of these, only the fans 3 and 4 in the two openings 7 and 10 are to be seen in Figs 1 and 3, but it will be appreciated that corresponding arrangements are to be found at the other two openings 19 and 23. All fans are adapted to generate airflows which are directed into the associated duct and which are illustrated by arrows F1, F2, F4 and F5 in Fig. 2. In the ducts 6, 18, the airflows are diverted by the duct walls towards each other and they meet at the respective third opening 12, 26 and there again leave the duct, which in Fig. 2 is illustrated by arrows F3, F6.

Arrows F1 and F3 also illustrate with their associated wave-shaped symbol that the airflow which they represent has a different temperature from the airflows passing into the fan unit 1. In the unit 1 shown in Figs 1-3, whose large face 20 is intended to be directed towards said apparatus housing C and whose openings 19, 23, 26 therefore communicate with the inside of the housing C, the airflows F4 and F5 directed into the openings 19 and 23 thus have a higher temperature than the airflow F6 directed away from the opening 26 while in the openings 7, 10, 12 in the opposite large face 8 of the unit 1, said openings communicating with the outside of the housing C, the airflows F1 and F2 directed into the open-

ings 7 and 10 have a lower temperature than the airflow F3 directed away from the opening 12. The reason for this is that between the two ducts 6, 18 of the unit 1 heat exchange is effected by means of a heat-exchanging element 2 which is common to both ducts. This will be described in more detail below by way of a second embodiment of the fan unit and with reference to Figs 4 and 5.

As is evident from Figs 4 and 5, a fan 3 is mounted in the opening 7 and a fan 22 is mounted in the opposite opening 19. Between these fans 3 and 22 the two separate ducts 6, 18 are formed, which in the longitudinal direction of the unit 1 extend up to the pair of fans at the opposite end of the unit 1. The two ducts 6, 18 are separated by said heat-exchanging element 2, which in the shown embodiments consists of a thin aluminium sheet bent in a meandering manner. This forms a plurality of ridges 30 extending in the longitudinal direction of the unit 1, and intermediate troughs 31, and divides the two ducts 6, 18 into a plurality of parallel passages 32 which jointly have a very large surface which is favourable for heat exchange.

Fig. 4 also shows how the electric connection of the fan unit 1 according to the invention can be designed. To the left in this figure, a switch box 33 is shown, from which lines 34-37 extend to be connected to the four fans 3, 4, 22, 25. Moreover, two lines 38, 39 extend from the switch box 33 and connect two temperature sensors 27, 28 (indicated in Fig. 2 by dashed lines) with control equipment in the switch box 33, the temperature sensors 27, 28 being arranged at the third opening 26 of the second duct 18, said third opening leading into said apparatus housing C. The different operational conditions which are feasible with such a temperature sensor and fan arrangement has been described in detail above and need not be repeated.

Figs 6-9 illustrate the currently preferred embodiment of the present invention. This comprises a fan unit

1 with a first duct 6 of the same type as in the above-described embodiments and a heat-exchanging element 2 having a back 17 which is formed inside a second tubular duct 18. This has a first duct opening 19 formed in a duct wall 20 at a first end 21 of the duct 18, and a second duct opening 23 formed in the duct wall 20 at an opposite end 24 of the duct 18. A fan 22 is arranged in the second duct opening 23 to generate in an extracting manner an airflow F4, F6 which flows into the second duct 18 through the first duct opening 19 and out of this duct 18 through the second duct opening 23.

In contrast to the embodiments described above, the third opening 12 of the first duct 6 is in the preferred embodiment arranged closer to the first than to the second opening 7, 10 since this has proved to result in a slightly higher degree of efficiency. Moreover, in the preferred embodiment a temperature sensor 29 is arranged to permit regulation of the speed of the first and the second fan 3, 4 in dependence on the temperature level in a chamber C, the sensing of temperature taking place at the second duct opening 23 of the second duct 18.

Those skilled in the art realise that the inventive fan unit 1 can be designed in many different ways within the scope of the claims and specifically that within this scope it is possible to arrange, in addition to said first and second duct opening and the intermediate third duct opening, additional openings provided with fans, and intermediate outlet openings so as to obtain either a higher cooling effect or still greater reliability in operation.

Those skilled in the art also realise that it is possible to arrange, within the scope of the claims, more than two thermosensors and associated thermostats for controlling, for example, four fans in a plurality of cooling effect steps.

CLAIMS

1. A fan unit for cooling of heat-generating equipment (E), such as electric components, said unit comprising an air-cooled heat-exchanging element (2) which is adapted to remove heat from said equipment (E), and at least two fans (3, 4) which are adapted to blow air towards the heat-exchanging element (2) to increase its heat removing effect, characterised in that the heat-exchanging element (2) has a front (5) which is formed inside a first tubular duct (6) having a first duct opening (7) which is formed in a duct wall (8) at a first end (9) of the duct (6) and through which a first fan (3) is adapted to blow air towards the front (5) of the heat-exchanging element (2), a second duct opening (10) which is formed in the duct wall (8) at an opposite end (11) of the duct (6) and through which a second fan (4) is adapted to blow air towards the front (5) of the heat-exchanging element (2), and a third duct opening (12) which is formed between the first and the second duct opening (7, 10), so that airflows (F1, F2) generated by the first and the second fan (3, 4) meet at the third duct opening (12) to leave the duct (6) in the form of one airflow (F3) through said opening (12).

2. A fan unit as claimed in claim 1, characterised in that the duct openings (7, 10, 12) are formed in the duct wall (8) opposite to the heat-exchanging element (2).

3. A fan unit as claimed in claim 1 or 2, characterised in that a first temperature sensor (13) is adapted to connect, by means of a thermostat, the first fan (3) when a first temperature level is exceeded, and that a second temperature sensor (14) is adapted to connect, by means of a thermostat, also the second fan (4) when a second temperature level which is higher than the first temperature level is exceeded.

4. A fan unit as claimed in claim 3, c h a r a c t e r i s e d in that the temperature sensors (13, 14) are adapted to sense the temperature levels at the third duct opening (12).

5. A fan unit as claimed in any one of claims 1-4, c h a r a c t e r i s e d in that the heat-exchanging element (2) is a cooling element provided with cooling flanges (15) which inside the duct essentially extend in the longitudinal direction of the duct (6) so as to divide the same into a plurality of parallel passages (16).

6. A fan unit as claimed in claim 1 or 2, c h a r a c t e r i s e d in that the heat-exchanging element (2) has a back (17) which is formed inside a second tubular duct (18) having a first duct opening (19), which is formed in a duct wall (20) at a first end (21) of the duct (18) and through which a third fan (22) is adapted to blow air towards the back (17) of the heat-exchanging element (2), a second duct opening (23), which is formed in the duct wall (20) at an opposite end (24) of the duct (18) and through which a fourth fan (25) is adapted to blow air towards the back (17) of the heat-exchanging element (2), and a third duct opening (26), which is formed between the first and the second duct opening (19, 23), so that airflows (F4, F5) generated by the third and the fourth fan (22, 25) meet at the third duct opening (26) to leave the duct (18) in the form of one airflow (F6) through said opening (26).

7. A fan unit as claimed in claim 6, c h a r a c t e r i s e d in that the duct openings (19, 23, 26) are formed in the duct wall (20) opposite to the heat-exchanging element (2).

8. A fan unit as claimed in claim 6 or 7, c h a r a c t e r i s e d in that the second duct (18) communicates with a hermetically sealed chamber (C) in which said heat-generating equipment (E) is arranged.

9. A fan unit as claimed in claim 8, c h a r a c t e r i s e d in that a first temperature sensor (27) is adapted to connect, by means of a thermostat, a fan (3, 4) at the first duct (6) and a fan (22, 25) at the second duct (18) when a first temperature level is exceeded inside the chamber (C), and that a second temperature sensor (28) is adapted to connect, by means of a thermostat, also the remaining fans (3, 4, 22, 25) when a second temperature level which is higher than the first temperature level is exceeded inside the chamber (C).

10. A fan unit as claimed in claim 9, c h a r a c t e r i s e d in that the temperature sensors (27, 28) are adapted to sense the temperature levels inside the chamber (C) at the third duct opening (26) of the second duct (18).

11. A fan unit as claimed in claim 1 or 2, c h a r a c t e r i s e d in that the heat-exchanging element (2) has a back (17) which is formed inside a second tubular duct (18) having a first duct opening (19) which is formed in a duct wall (20) at a first end (21) of the duct (18), and a second duct opening (23) which is formed in the duct wall (20) at an opposite end (24) of the duct (18), a third fan (22) being adapted to generate an airflow (F4, F6) flowing into the second duct (18) through the first duct opening (19) and out of the same duct (18) through the second duct opening (23).

12. A fan unit as claimed in claim 11, c h a r a c t e r i s e d in that the third opening (12) of the first duct (6) is arranged closer to the first than to the second opening (7, 10).

13. A fan unit as claimed in claim 11 or 12, c h a r a c t e r i s e d in that the duct openings (19, 23) are formed in the duct wall (20) opposite to the heat-exchanging element (2).

14. A fan unit as claimed in any one of claims 11-13, c h a r a c t e r i s e d in that the second duct

(18) communicates with a hermetically sealed chamber (16) in which said heat-generating equipment (E) is arranged.

15. A fan unit as claimed in claim 14, c h a r a c t e r i s e d in that a temperature sensor (29) is adapted to regulate the speed of the first and the second fan (3, 4) in dependence on the temperature level inside the chamber (C).

16. A fan unit as claimed in claim 15, c h a r a c t e r i s e d in that the temperature sensor (29) is adapted to sense the temperature level inside the chamber (C) at the second duct opening (23) of the second duct (18).

17. A fan unit as claimed in any one of claims 11-16, c h a r a c t e r i s e d in that the third fan (22) is arranged at the second duct opening (23) of the second duct (18).

18. A fan unit as claimed in any one of claims 6-17, c h a r a c t e r i s e d in that the heat-exchanging element (2) is a sheet metal element which is folded in an essentially meandering manner and which has ridges (30) and intermediate troughs (31) inside the ducts (6, 18), the ridges and the troughs (29, 30) extending in such manner in the longitudinal direction of the ducts (6, 18) that these are each divided into a plurality of parallel passages (32).

1/4

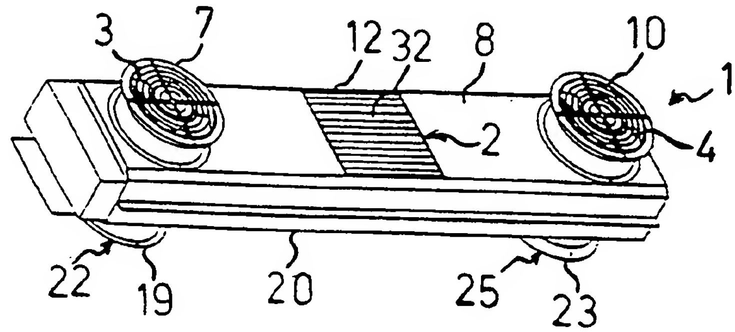

FIG 1

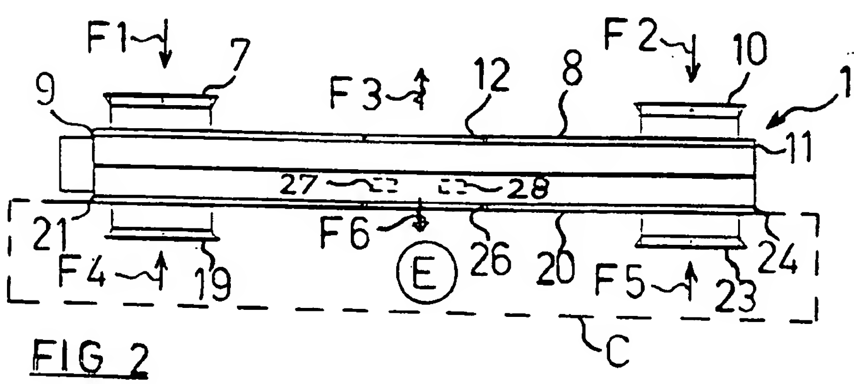

FIG 2

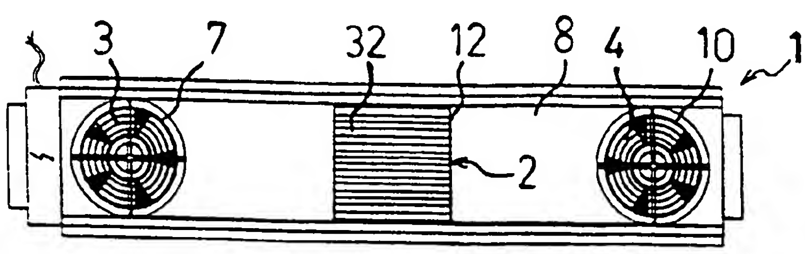

FIG 3

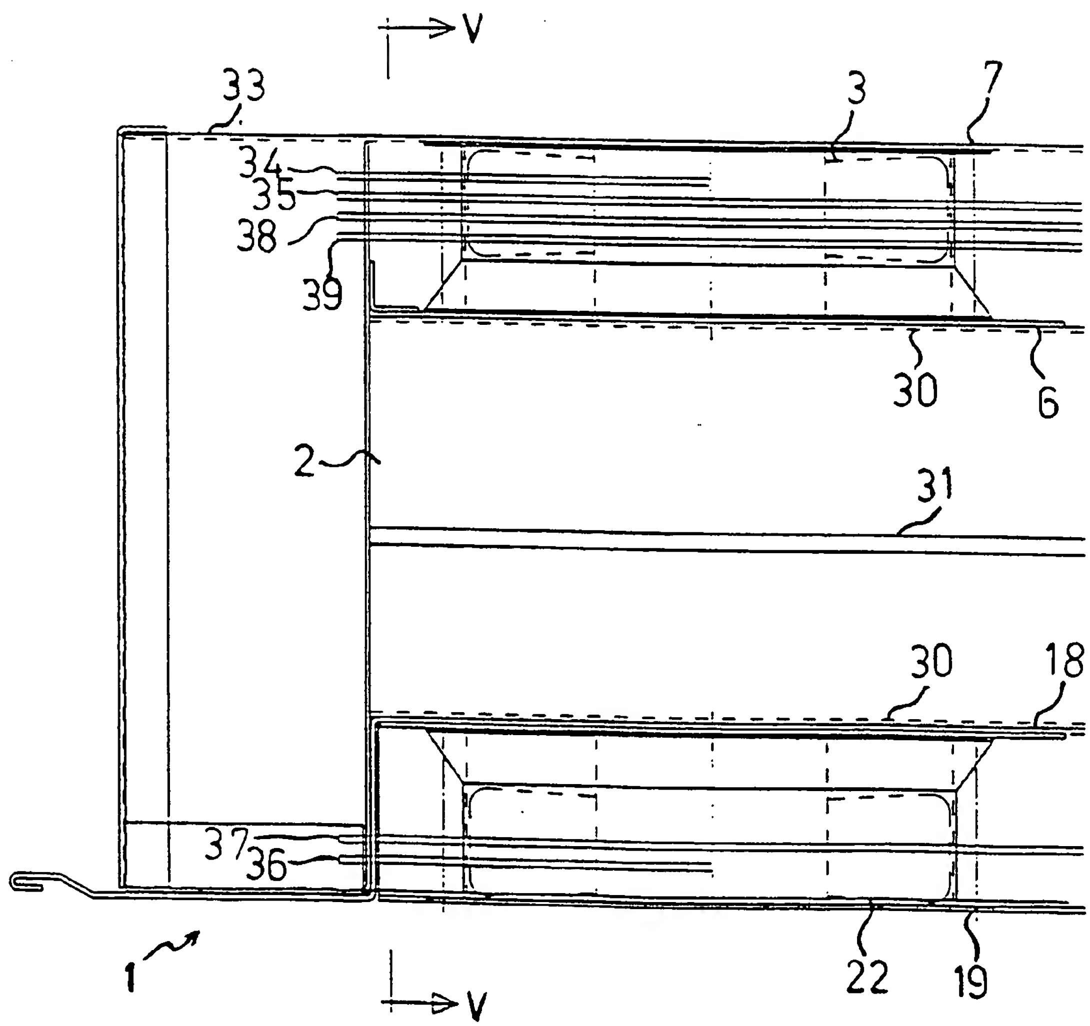

FIG 4

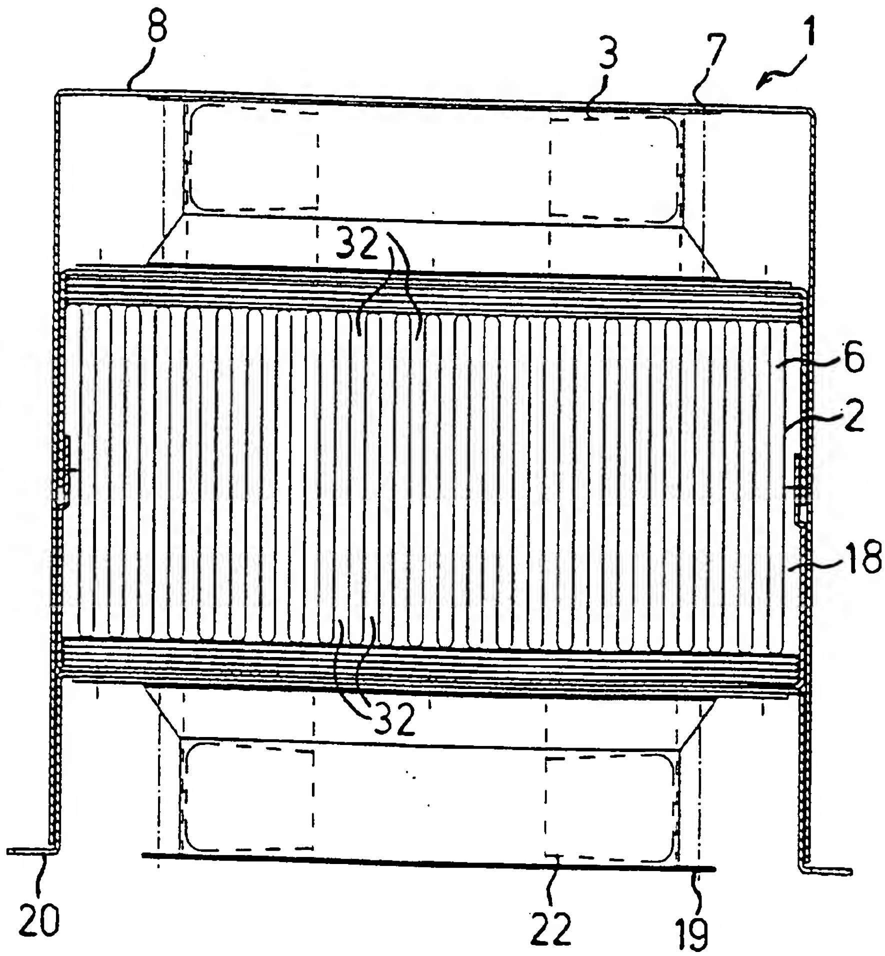

FIG 5

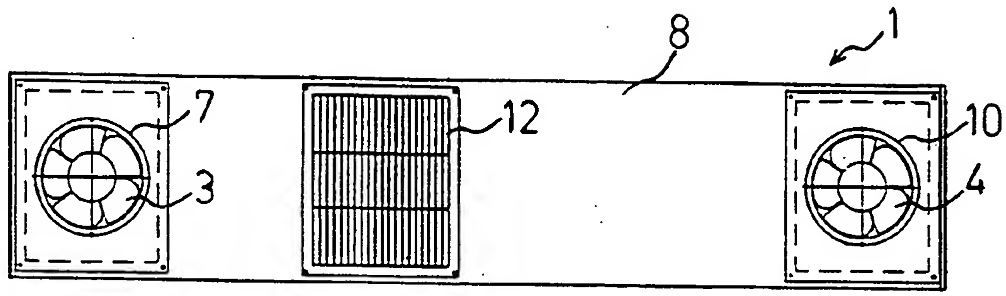

FIG 6

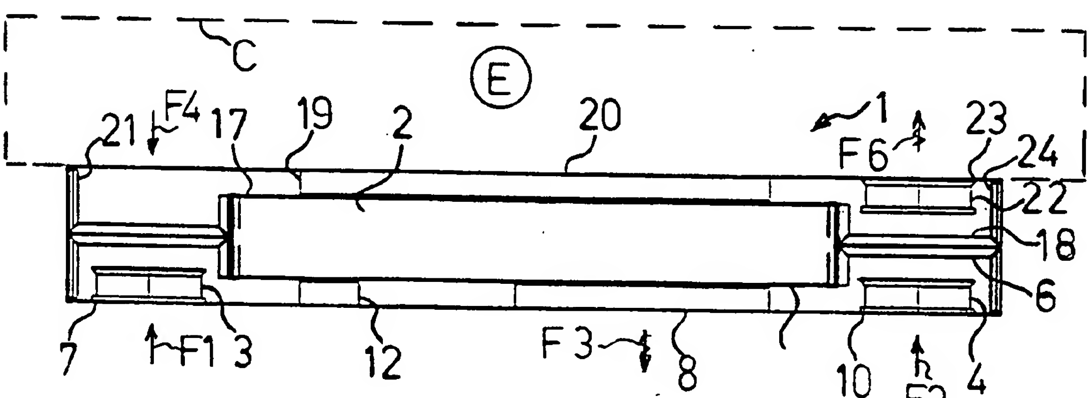

FIG 7

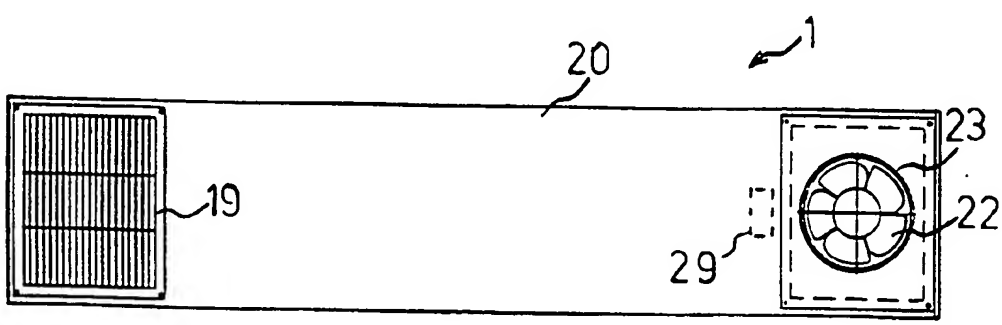

FIG 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00148

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H05K 7/20, F28D 7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H05K, F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4648007 A (ROBIN E. GARNER), 3 March 1987 (03.03.87), column 1, line 54 - column 2, line 9, figures 1-5	1-18
	--	
A	US 5638895 A (DOUGLAS A. DODSON), 17 June 1997 (17.06.97), figure 1, abstract	1-18
	--	
A	US 5738166 A (CHING-LONG CHOU), 14 April 1998 (14.04.98), column 1, line 23 - column 2, line 5, figure 1	1-18
	--	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 April 2000	15-05-2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Fredrik Liljegren/mj Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99	International application No. PCT/SE 00/00148

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4648007 A	03/03/87	NONE	
US 5638895 A	17/06/97	US 5787971 A	04/08/98
US 5738166 A	14/04/98	NONE	

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